Claims

What is claimed is:

1. A system for determining at least one condition of a bearing, comprising:

at least one optical fiber embedded in a bearing, the at least one optical fiber being adapted to transmit light from a light source; and

an interferometric system operatively coupled to the optical fiber and a processor;

wherein the interferometric system provides the processor with information relating to at least one condition of the bearing, and the processor determines a state of the at least one condition of the bearing based on the information.

2. The system of claim 1, wherein the processor determines rate of wear of the bearing based on the information.

3. The system of claim 1, wherein a length direction of the optical fiber is substantially parallel to a direction of wear of the bearing.

4. The system of claim 1, wherein the interferometric system generates a reference beam and a measuring beam from the light source, the measuring beam being transmitted through the optical fiber.

5. The system of claim 4, wherein the interferometric system generates an interference beam from a reflected reference beam and a reflected measuring beam.

6. The system of claim 5, wherein the interference beam includes at least one fringe, the at least one fringe corresponding to a change in length of the optical fiber.

7. The system of claim 6, further including a counter for counting the at least one fringe.

8. The system of claim 1, wherein the bearing is a ball bearing and includes at least one optical fiber in an inner race of the bearing at least one optical fiber in an outer race of the bearing.

9. The system of claim 1, wherein the bearing includes a plurality of optical fibers in the inner race of the bearing and a plurality of optical fibers in the outer race of the bearing.

10. The system of claim 1, wherein the at least one condition is wear of the bearing.

11. The system of claim 1, wherein at least one optical fiber is grated and coupled to a temperature sensor and the at least one condition is temperature environment of the bearing.

12. The system of claim 1, wherein at least one optical fiber includes microbends and is coupled to a pressure sensor and the at least one condition is the pressure environment of the bearing.

13. The system of claim 1, further comprising an actuator coupled to the processor and coupled to the interferometric system, the processor and the actuator cooperating to maintain a fixed fringe pattern based on readings the processor receives from the interferometric system.

14. The system of claim 1, wherein the bearing is one of a sleeve bearing, a hydrodynamic bearing, a double row ball bearing and a thrust bearing.

15. The system of claim 1, wherein the at least one optical fiber comprises a plurality of optical fibers sharing the interferometric system and the processor.

16. A system for determining at least one condition of a bearing, comprising:

a light source for generating a beam of light;

at least one optical fiber at least part of which is embedded in a bearing, the at least one optical fiber having first and second ends, the first end receiving the beam of light, the second end being flush with a contacting surface of the bearing; and

a measuring system operatively coupled to the optical fiber;

wherein the optical fiber provides the measuring system with information relating to the at least one condition of the bearing.

17. The system of claim 16, the measuring system includes an interferometric system and a processor.

18. The system of claim 16, wherein a length direction of the at least one optical fiber is substantially parallel to a direction of wear of the article

19. The system of claim 16, wherein the at least one condition is wear of the bearing.

20. The system of claim 16, wherein at least one optical fiber is grated and coupled to a temperature sensor and the at least one condition is temperature environment of the bearing.

21. The system of claim 16, wherein at least one optical fiber includes microbends and is coupled to a pressure sensor and the at least one condition is pressure environment of the bearing.

22. A bearing of a dynamoelectric machine, the bearing having at least one optical fiber embedded therein.

23. The bearing of claim 22, wherein a length direction of the at least one optical fiber is substantially parallel to a wear direction of the bearing.

24. A method for determining at least one condition of a bearing, comprising the steps of:

providing a bearing having an optical fiber embedded therein;

using a measuring system operatively connected to the optical fiber to collect information relating to the optical fiber; and

using a processor operatively coupled to the measuring system to determine the at least one condition of the bearing based on the information.

25. The method of claim 24, the at least one condition being bearing wear rate.

26. The method of claim 24, the at least one condition being bearing temperature environment.

27. The method of claim 24, the at least one condition being bearing pressure environment.

28. A system for determining the amount of material removed in a semiconductor process, comprising:

a light source for generating a beam of light;

at least one optical fiber at least part of which is embedded in a semiconductor device, the at least one optical fiber having first and second ends, the first end receiving the beam of light, the second end being flush with a contacting surface of the semiconductor device; and

a measuring system operatively coupled to the optical fiber;

wherein the optical fiber provides the measuring system with information relating to an amount of material removed from the semiconductor device.

29. The system of claim 28, the measuring system includes an interferometric system and a processor.

30. The system of claim 28, the information relating to an amount of material removed from the semiconductor being the amount of material removed during an etching process of a via.

31. The system of claim 28, the information relating to an amount of material removed from the semiconductor being the amount of material removed during a chemical mechanical polish step.

32. The system of claim 28, wherein the a length direction of the at least one optical fiber is substantially parallel to a removal direction of the semiconductor device.

33. The system of claim 28, wherein the measurement system further comprises an actuator coupled to a processor and the actuator coupled to optics of the measurement system, the processor and the actuator cooperating to maintain a fixed fringe pattern based on readings the processor receives from a detector in the measurement system, the detector receiving readings from the optical fiber.

34. A system for determining wear of a polishing pad, comprising:

at least one optical fiber embedded in a polishing pad, the at least one optical fiber being adapted to transmit light from a light source; and

an interferometric system operatively coupled to the optical fiber and a processor;

wherein the interferometric system provides the processor with information relating to wear of the polishing pad, and the processor determines a state of the polishing pad based on the information.

35. The system of claim 34, wherein the processor determines rate of wear of the polishing pad based on the information.

36. The system of claim 34, wherein a length direction of the optical fiber is substantially parallel to a direction of wear of the polishing pad.

37. A system for determining at least one condition of a bearing, comprising:

at least one optical fiber embedded in a bearing, the at least one optical fiber being adapted to transmit light from a light source;

an interferometric system operatively coupled to the optical fiber and a processor, the interferometric system comprising optics and a detector, the light source transmiting

light from the light source to the at least one fiber which is reflected from the optics to the detector;

an actuator coupled to the processor and the optics wherein the processor controls the actuator to adjust the optics based on at least one condition of the bearing.

38. The system of claim 37, the processor further providing at least one of diagnostics and prognostics information.

39. The system of claim 37, further comprising a plurality of interferometric systems each coupled to a processor wherein each of the plurality of interferometric systems employ the light source utilizing an optical coupler to split the light from the light source to the plurality of interferometric systems.

40. The system of claim 37, the at least one optical fiber comprising a plurality of optical fibers embedded in a plurality of devices, the plurality of optical fibers sharing the light source, the interferometric system and the processor.

41. The system of claim 37, the at least one optical fiber comprising a plurality of optical fibers measuring a plurality of condition of the bearing, the plurality of conditions being combined using sensor fusion to provide an output of at least one of health state, fault condition, control action, warning and recommendation action.

42. The system of claim 37, the at least one optical fiber, the light source, the interferometric system, the processor, the detector, the actuator being integrated into the bearing to form a smart bearing.

43. The system of claim 37, wherein the bearing is a babbitt and the processor predicts when the babbitt needs to be replaced.